The acute effects of static-stretching, dynamic exercise and combined warm-up protocols on the speed, agility and muscular power of trained youth rugby union players

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ABSTRACT

Several minutes of low intensity aerobic exercise followed by static stretching is typically administered and considered the norm for youth performers. While the active aerobic component of a warm-up has been demonstrated to improve short term, intermediate and long term performance, scientific evidence supporting the performance attributes of warm ups including static stretching are sparse. As a result there has been a growing interest in warm-up procedures that involve dynamic exercise. Consequently, the purpose of this study was to examine the differing acute effects of a dynamic exercise warm-up with that of a static stretching warm up and a combination warm up (static and dynamic) on the sports specific actions of youth rugby union players; namely speed, agility and muscular power. 20 male youth (age 12-13) rugby union players participated in a Vertical Jump, 'L run' and 20 meters sprint after three different warm-up protocols. All sessions were administered in a random order with at least 3 days apart. Before testing, participants performed 5 min of walking/jogging followed by one of the following warm-up protocols: a) six static stretches (2 × 15 s) designed to replicate a typical youth team procedure, or b) ten low to high-intensity dynamic movements (2 × 15 meters), or c) 5 low to high-intensity dynamic movements (2 × 15 meters) interspersed with 5 static stretches for the major muscle groups (2 × 15 s). After each warm-up routine, participants performed the selected tests designed to measure muscular power, speed, and agility. Each subject completed all test with each warm up protocol within 21 days.
Statistical analysis of the data revealed that on all tests, except 20 meters sprint , the dynamic exercise warm-up significantly (p <0.017) improved performance over the static stretching and combination protocols. Performance on the 20 meters sprint was significantly improved after the dynamic protocol than after the static but not the combination protocol.The results of this study indicate that pre-event dynamic exercise might be more beneficial than both pre-event static stretching and combination warm up protocols for preparing for performance in youth rugby union players and youth sports of a similar nature.

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Finally, thanks to the great words of Dr. Emmett Brown:

'If you put your mind to it, you can accomplish anything'.

This work is original and has not been previously submitted of a degree, qualification or other course.

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CHAPTER 1

INTRODUCTION

The concept of a warm up has long been considered an integral component of preparing athletes and sports participant's musculoskeletal system before physical activity (Asmussen and Boje 1945). However, definitive scientific evidence supporting one method over another is at presently lacking, and as a result most warm ups protocols tend to be based heavily on traditional values and the experience of coaches and athletes (Bishop 2003; Mcmillian et al 2006). Several minutes of low intensity aerobic exercise followed by static stretching is typically administered and considered the norm (Faigenbaum et al 2005; Young and Behm 2003; Vigillio 1997). While the active aerobic component of a warm-up has been demonstrated to improve short term, intermediate and long term performance (Bishop 2003), scientific evidence supporting the performance attributes of warm ups including static stretching are sparse. While chronic static stretching has been found to be an effective method of increasing range of movement at a particular joint (Taylor et al 1990), a number of authors have reported that an acute bout of pre-exercise static stretching may actually reduce performance in a number of tasks in both adults (Evetovich et al 2003; Fowles et al 2000) and youths (Mcneal and Sands 2003; Siatras et al 2003). Nonetheless, the combination of warm up and static stretching is advocated by popular literature and utilized by both younger and older populations (Martens 2004; Vigilio 1997).

Recently, there has been a growing interest in warm-up procedures that involve a more dynamic type warm up, incorporating movements that are designed to enhance motor unit excitability, raise core temperature, improve kinaesthetic awareness, and facilitate active ranges of motion (Fredrick et al 2001; Mann 1999; Ruteledge and Faccioni 2001). This type of functionally based warm-up is known as dynamic exercise (Fredrick et al 2001). Researchers have illustrated that a dynamic exercise warm up can enhance performance in comparison to static stretching conditions, across a multitude of tasks, in youths (Faigenbaum et al 2005; Fagenbaum et al 2006a; Faigenbaum et al 2006b; Siatras 2003;) and adults (Burkett et al 2005; Fletcher and Jones 2004; Little and Williams 2006 ; Mcmillian et al 2006). Although many variations of a dynamic warm-up exist most feature progressive exercise movements such as hops, skips, jumps, and various movement-based exercises for the upper and lower body (Fredrick et al 2001; Mann 1999; Ruteledge and Faccioni 2001). Unsurprisingly, as a result of the detrimental research addressing warm-ups involving static stretching and the favourable research on dynamic warm ups, athletes have began moving away from the static method and began to implement dynamic exercise warm ups (Fletcher et al 2004).

A number of researchers and strength and conditioning have supported the move away from static stretching warm-ups, advocating that sports performers should replace the traditional pre- exercise static stretching approach with dynamic exercise (Fredrick et al 2001; Mann 1999 Ruteledge and Faccioni 2001). However these notions and recommendations may be questionable as many of the warm up protocols and tests utilized in past studies are not representative of typical warm up methods employed by sports participants, or physical performance parameters related to the demands of specific sports. Moreover, limited research exists utilizing combined static and dynamic exercise warm-ups. In theory it could be suggested that dynamic exercise, specific to a sporting event, could be used to raise the athlete's core temperature and prepare for the subsequent sports movements, and interspersed short duration static stretching could be used to acutely and chronically increase ranges of movement.

Therefore In view of the fact that, several minutes of low intensity aerobic exercise followed by short-duration static stretching exercises is still recommended by professional organizations and continues to be part of the warm-up protocol for most youth sports (NASPE 2005; Faigenbaum & McFarland 2007b; Alter 2004; ACSP2000; Holcomb 2000; Martens 2004; Vigilio 1997); it would be beneficial to compare the performance outcomes of a typical youth team warm up with a dynamic warm in a sports specific context. Furthermore, given that there is currently limited evidence with combinations of static stretching and dynamic exercise protocols, the outcome of an amalgamated static and dynamic warm on a specific sporting population would also provide worthwhile results.

Consequently, the purpose of this study was to examine the differing acute effects of a typical youth team static stretching warm up with that of a dynamic exercise warm up and a combination (dynamic and static stretching) warm up on the sports specific actions of youth rugby union players; namely speed, agility and muscular power. This data, despite its ecological shortcomings will provide external validity to youth rugby, helping to identify the most effective warm-up protocol for optimizing performance. Furthermore as these attributes (speed, agility, and muscular power) are common requirements for similar sports the information generated will be valuable to coaches, young athletes and physical education teachers who typically administer warm up activities. Given that dynamic exercise has been shown to increase performance on a multitude of tasks and the detrimental research addressing static stretching, the researcher hypothesized that a warm up consisting solely of dynamic exercise would result in superior performance on speed, agility and muscular power in trained youth rugby union players.

CHAPTER 2

LITERTAURE REVIEW

2.1 The warm up

The warm up is a widely accepted practice preceding sports participation (Bishop 2003), defined as a process to prepare the body for action via increased muscle and tendon suppleness, stimulated blood flow to the peripheral, increased body temperature, and enhanced free coordination movement (Smith 1994). However, while the warm up is considered to be essential for optimum performance, definitive scientific evidence supporting one method over another is at presently lacking. As a result most warm ups protocols tend to be based heavily on traditional values and the experience of coaches and athletes (Bishop 2003; Mcmillian et al 2006). Several minutes of low intensity aerobic exercise followed by static stretching is typically administered and considered the norm (Faigenbaum & McFarland 2007b; Faigenbaum et al 2005; Vigillio 1997; Young and Behm 2003). While the active aerobic component of a warm-up has been demonstrated to enhance short term, intermediate and long term performance (see Bishop 2003 for review), scientific evidence supporting the performance attributes of warm ups including static stretching are sparse (for the purpose of this study static stretching is defined as moving a limb to the end of its range of motion and holding it in a stretched position).

2.2 Traditional beliefs surrounding static stretching

The ingrained notion and belief that static stretching is an integral and essential part of the warm up has stemmed from the premise that decreased muscle stiffness resulting from the stretching, will reduce the amount of force required to move the limb through a greater range of motion (Shellock and Prentice 1985). In theory, this notion would allow for a stretching induced increase in performance and a reduction in the risk of injury (Alter 1996). Although acute and long term (chronic effect) static stretching has been found to reduce muscle tension and increase range of movement [ROM] (Mcnair et al 1996; Taylor et al 1990) the belief that pre-event protocols that include static stretching will also reduce the risk of injury and enhance performance has little convincing scientific evidence. In fact, new research has challenged some of the long held concepts about static stretching routines, highlighting that far from helping athletes, pre-activity static stretching may inhibit performance (e.g. Evetovich et al 2003).

2.3 Detrimental research on acute static stretching

Studies have suggested that an acute bout of pre-event stretching may have an inhibitory effect on a multitude of tasks in adults including: maximal force or torque production (Siatras et al 2008; Behm et al 2001;Cramer et al 2004; Cramer et al 2005; Evetovich et al 2003; Fowles et al 2000; Kokkonen et al 1998; Marek et al 2005; Mclellan 2000; Nelson et al 2001; Power et al 2004), jump performance (Holt & Lambourne 2008 ;Vetter 2007; Church et al 2001; Cornwell et al 2001;Mcneal et al 2003; Young and Elliott 2001, Young et al 2003), sprint performance(Winchester et al 2008; Fletcher and Jones 2004), agility tests (Little and Williams 2006; Mcmillian et al 2006) reaction time, balancing tasks (Behm et al 2004) and muscle strength endurance tests (Arnold et al 2005). For example, Fowles et al (2000) investigated the maximal isometric torque of the plantar flexor muscles following an acute bout of static stretching.

The study cited a reduction in performance of around 30% immediately after the bout of static stretching.

Several authors have also discovered similar consequences through pre-activity static stretching on muscle function in youths (Faigenbaum et al 2005; Faigenbaum et al 2006; Faigenbaum 2006b; Mcneal et al 2003; Siatras et al 2003). For instance, Faigenbaum et al (2005) reported that jumping, sprinting and shuttle run performance declined significantly in children after an acute bout of static stretching, and Siatras et al (2003) demonstrated that youth gymnasts' mean speed during the run of the vault was significantly decreased after the application of a static stretching protocol. Similarily, McNeal and Sands (2003) and Siatras et al (2003) also observed that static stretching had a negative effect on explosive force and speed development in boys and girls. Thus collectively these findings suggest that pre activity protocols that include static stretching might have an unintended adverse effect on power, speed and agility performance in both adults and youths.

2.4 Proposed reasons for reduction in performance after static stretching

The exact mechanisms responsible for a reduction in performance following static stretching have not yet been elucidated, however researchers have suggested several theories why pre-exercise stretching might decrease the subsequent tasks performance.

2.4.1 Neural inhibition and static stretching

Firstly, a number of authors have hypothesized that the reduction in performance is a result of reduced neural activation (Avela et al 1999; Behm et al2004; Fowles et al 2000; Kokkonen 1998; Knudson et al 2001; Rosenbaum et al 1995). Knudson et al (2001) cited that the significant decrease in performance of a vertical jump after a static stretching protocol was the result of an acute neural inhibition from the stretch which decreased neural drive and transmission, this conclusion was made as their investigation found no change in the kinematics of the jumping movement.

Studies addressing neural inhibition have indicated that neurological fatigue is triggered by a reduction in excitatory inputs (Hunter et al 2004; Gandevia 2001). Adam et al (2003) highlights that typically a decrease in neural excitation is compensated for by the increasing recruitment of new motor units, with the initial and the subsequent motor units complying to a specific and unchangeable pattern. Through electromyography and twitch interpolation techniques several studies have found that pre-event stretching causes a reduction in muscle activation (Fowles et al 2000; Behm et al 2001). Therefore, it seems viable that static stretching may induce a proportion of motor units into a fatigued state prior to the onset of the task resulting in a greater activation rate and a decreased pool of motor units available for activation, which would results in a faster rate of neural fatigue (Hunter et al 2004). Bosco et al (1982a; 1982b) fortify this argument proposing that the eccentric phase of a stretch initiates a myoelectric potentiation, thus causing a disruption of the stretch reflex activity increases muscle activation during the period of concentric work.

2.4.2 Musculotendinous stiffness and static stretching

On the other hand, another widely held rationale for a stretch-induced decline in performance is the possible mechanical mechanism of the stretch inducing a decrease in stiffness in the musculotendinous unit (Kokkonen et al 1998). Ingen (1984) first postulated that the amount of elastic energy that can be stored in the musculotendinous unit is a function of the unit's stiffness. More recently Wilson et al (1994) and Kokhonen et al (1998) upheld this theory suggesting that there is a significant relationship between musculotendinous and force production. The notion ascribing static stretching and musculotendinous stiffness is based on the premise that static stretching may change tendon structure, effectively causing an increased ‘slack’ in the musculotendinous system resulting in reduction in force production and a delay in muscle activation between the muscle and the skeletal system (Kokhonen et al 1998). Conversely, a stiffer system would, in theory, generate a greater length and a decreased shortening velocity of the contractile component, enhancing contractile component force production by enabling more favorable length and velocity conditions (Kokkonen et al 1998; Kubo et al 2001; Wilson et al 1994).

Several authors have attributed loses in performance to Musculotendinous stiffness. In concluding a study on jump performance and static stretching Young and Elliot (2001) stated that a decrease in muscle activation via stretching activity (regarding the preactivation of the musculotendinous unit) before performance reduced the stiffness of the unit prior to ground impact causing a negative performance outcome. This is also the supposition of Cornwell et al (2001) whom cited a decrease in drop jump performance was the result of the decreased ability of the musculotendinous unit to store and transfer elastic energy after the use of a stretching protocol. However, such notions are not withheld by all authors. Wilson et al (1994) ascribed that an increase in musculotendinous compliance resulted in an increase in bench press performance. Similarly Walshe & Wilson (1997) also theorized that an increase in depth jump performance was due to a more compliant musculotendinous unit. Walshe & Wilson (1997) concluded their study highlighting that it was the ability to stretch, store, and release elastic energy that allowed subjects to mitigate high loads placed on the unit.

2.4.3 Other proposed reasons

Similarly, it has also been suggested that stretching may trigger an acute response of muscle and/or joint proprioceptors, sending the Golgi tendon organs into an autogenic inhibition of the muscle being stretched and its synergists (Moore1984). Rosenbaum et al (1995) whom found that 10 minutes of treadmill running after static stretching reversed the reduction in active peak force and rate of force development yet retained the improved stretch-absorbing capacity ascribed that the reduction in maximal force production they observed to a consequence of a depressed H-reflex through acute static stretching. Other authors have hypothesized that blood flow through the muscle may be impaired whilst being stretched, which in turn may effect force production through either low oxygen supply or impaired removal of metabolic by products (Mcneal et al 2003).

2.5 The widespread use and support of static stretching during the warm-up

Interestingly, several studies have indicated that pre event static stretching may not offer the presumed benefit of injury risk reduction (Black et al 2001; Gleim et al 1997; Herbert et al 2002; Pope et al 2000; Shrier 1999). Ironically then, a coach prescribing pre-event static stretching with aspirations of increasing performance and reduce injury might actually be gaining no benefits at all. Notwithstanding, the widespread use of static stretching convincing scientific evidence documenting the benefits of performance following acute static stretching are limited. Nonetheless, the combination of warm up and static stretching is advocated by popular literature for younger and older populations (Martens 2004; Vigilio 1997).

2.6 Youth sports and static stretching

Particularly in youth sports, static stretching has become synonymous with warm-up activities (Faigenbaum & McFarland 2007b). Youth coaches persuaded by traditional methods regarding the value of pre-event static stretching to improve performance and decrease the risk of injury will typically advocate static stretching as the conclusion of a warm-up (Faigenbaum et al, 2005; Faigenbaum et al 2006a). In fact, you can almost go anywhere in the world, from infant school to young amateurs, and see most practices begin with a relatively low intensity aerobic component such as jogging followed by stretching of specific muscles (Alter 2004; Anderson et al 2000; Faigenbaum et al 2005; Young and Behm 2003; Vigillio 1997; Anderson et al 2000). Warm-up procedures that include static stretching have also become an accepted practice in physical education literature (Vigilio 1997) and sports coaching programs (Holocomb 2000). Furthermore several minutes of low intensity aerobic exercise followed by short-duration (10-30 seconds) static stretching exercises are recommended by several professional organizations (NASPE 2005; Faigenbaum & McFarland 2007b; Alter 2004; ACSP2000; Holcomb 2000; Martens 2004; Vigilio 1997). For example, the National Association for Sport and Physical Education (NASPE) recognizes the importance of a general warm-up, and recommends five to ten minutes of a cardiovascular warm-up activity followed by short duration static stretching (NASPE, 2005). Clearly such literature adds to the mounting paradox between long-established dogma and tangible research evidence surrounding the correct warm up procedure to prepare and enhance performance, which could manifest confusion in athletes and coaches.

2.7 Dynamic exercise

Recently, there has been a growing interest in warm-up procedures that involve a more dynamic type warm up, incorporating movements that are designed to enhance motor unit excitability, raise core temperature, enhance kinaesthetic perception, and facilitate active ranges of motion (Faigenbaum & McFarland 2007a; Fredrick et al 2001; Mann 1999; Ruteledge and Faccioni 2001). This type of functionally based warm-up is known as dynamic exercise (Fredrick et al 2001). A dynamic exercise warm-up is defined as controlled movements through the active ranges of motion for each joint featuring progressive exercise movements for the upper and lower body, such as jumps, skips, hops, lunges and squats together with forward, backwards and lateral rapid acceleration running movements (Fredrick et al 2001; Mann 1999; Ruteledge and Faccioni 2001).

2.8 Acute effects of dynamic exercise warm-ups

Researchers have illustrated that a dynamic exercise warm up can enhance performance in comparison to static stretching and control conditions, across a multitude of tasks, in both youths (Faigenbaum et al 2005; Fagenbaum et al 2006b; Faigenbaum et al 2006b; Siatras 2003;) and adults (Burkett et al 2005; Fletcher et al 2004; Little et al 2006 ; Mcmillian 2006). For instance, Mcneal et al (2003) discovered that an acute bout of dynamic exercise increased vertical jump height in teenagers compared to that of a static stretching warm up. More recently Faigenbaum et al (2005) observed that warm up protocols that included dynamic exercise resulted in significantly superior performance on fitness performance (vertical jump, long jump and shuttle run) in children compared to a static protocol. Likewise Fletcher and Jones (2004) found a significant decrease in 20-m sprint performance after static stretching and a significant increase in performances post-dynamic exercise. In support of these observations, Faigenbaum et al (2006) also reported that pre-event static stretching followed by dynamic exercise was more beneficial than static stretching alone in teenage athletes who performed power activities. Furthermore pre-event warm up treatments that include dynamic type activities such as plyometrics, heavy load resistance exercise, or maximum voluntary contractions have also been shown to act favorably on muscle strength and power production (Gullich et al 1996; Masamoto et al 2003; Young et al 2003). Collectively these findings suggest that pre-activity protocols that include dynamic type exercise might have a performance enhancing effect on power, speed and agility performance in youths.

2.9 Proposed reasons for enhancement in performance after dynamic exercise

The exact mechanisms responsible for the enhancement in performance following a dynamic exercise warm-up have not yet been elucidated; researchers have suggested a number of rationales why dynamic exercise might increase the subsequent tasks performance.

2.9.1 Core temperature and dynamic exercise

Several researchers have attributed the positive effects on performance via dynamic exercise to a greater increase in muscle and core temperature than other forms of warm up (Fletcher et al 2004). An increase in core and muscle temperature has been reported to decrease the stiffness of muscles and joints (Butchthal et al 1944; Wright et al 1961), increase the transmission rate of nerve impulses (Karvonen 1992), change the force-velocity relationship (Binkhorst et al 1977; Ranatunga 1987) and to increase glycogenolysis, glycolysis and high energy phosphate degradation (Edwards et al 1972; Febbraio et al 1996). Thus via a dynamic warm up these variables could collectively, potentially augment performance by encouraging muscle contractions to be more rapid and forceful. Furthermore it has been suggested that a more active warm up (such as dynamic exercise) may also improve performance via an improved additional metabolic cost by decreasing the initial oxygen deficit, allowing for a greater anaerobic capacity for later in the task (Gollnick 1973; Ingjer et al 1979; McCutcheon et al 1999). Faigenbaum et al (2005) illustrated the contrasting metabolic costs between a traditional static stretching warm up and a dynamic warm up. During a traditional warm-up (low-intensity aerobic exercise and static stretching) heart rate averaged 109 beats per minute, whereas a dynamic warm-up protocol elicited an average heart rate of about 150 beats per minute (Faigenbaum et al., 2005). Therefore logically a dynamic warm up may facilitate subsequent performance via an improved additional metabolic cost.

2.9.2 Post activation potential and dynamic exercise warm-up

In addition to metabolic related changes, several authors have referred to a neuromuscular phenomenon as consequence of the dynamic warm up that could potentially enhance performance, known as Post Activation Potential (PAP) (Faigenbaum 2006a; Sale 2002; Shellock et al 1985). Sale (2002) defines PAP as an increase in muscle twitch force and rate of force development following a conditioning contractile activity. Golhofer et al (1988) and Hamada (2000) both illustrated that the phenomenon appears to have its greatest effect on fast twitch muscle fibers, and Stewart et al (2003) recently demonstrated an increase in EMG activity and power performance following the use of a dynamic warm-up protocol. Therefore, potentially a dynamic exercise warm up could increase PAP by pre -enhancing the excitability of the fast- twitch units before performance and therefore increasing the rate of force development. Although the optimal parameters to exploit PAP are currently unknown and further study is warranted, theoretically this phenomenon could improve attributes such as speed, agility and power performance.

2.9.3 Motor control and dynamic exercise warm-ups

Other authors have speculated that the positive changes in performance via a dynamic exercise warm up may have stemmed through the rehearsal of specific movements in a pattern that relates to the subsequent performance, allowing for a greater facilitation of motor control (Clark 2000; Fletcher et al 2004; Young et al 2003).Young et al (2003) demonstrated this notion, reporting that practice of the task activity as part of the warm up produces significantly greater results than a warm-up with out practice. Clearly it is plausibly that the rehearsal of movement in a more specific pattern than other warm ups (e.g. static stretching) may effectively open up specific neural pathways to facilitate motor unit activation, and in so doing enhancing the readiness of the neuromuscular system. Considered this way, a case could also be made for the motivational aspects of the dynamic warm up. Unlike low-intensity aerobic exercise and static stretching, performance of dynamic movements during the warm-up period may not only excite the neuromuscular system, but also provide an opportunity to prepare, motivate learn and practice movement patterns that are required for the demands of the sport. Clearly, If the warm-up is slow and monotonous (e.g., walking or jogging followed by static stretching), then the motivation be may be less than expected.

2.10 Support for the dynamic exercise warm-up

Unsurprisingly, as a result of the detrimental research addressing static stretching and the favourable research on dynamic warm ups, some athletes have moved away from the static method and began to implement dynamic type warm ups (Fletcher 2004). A number of researchers and strength and conditioning have also supported this move, advocating that sports performers should replace the traditional pre- exercise static stretching approach with dynamic exercise (Faigenbaum & McFarland 2007a; Fredrick et al 2001; Mann 1999; Ruteledge and Faccioni 2001).

2.11 Sports application- Issues with past studies

However the notions and recommendations to move away from static stretching towards solely dynamic exercise warm ups may be premature and questionable. Clearly there is a range of evidence indicated that an acute bout of static stretching can have a negative, whilst a more dynamic warm up can have positive influence on performance. However directly summarising the ecological validity of much of the past research on warm up techniques in terms of practical sports application to specific population is difficult due to the varying differences in a number of variables (e.g. physical maturity of the subjects, training status, training age, design of the warm-up protocols and sport or task utilised).

2.11.1 Stretching time length

Notably the vast majority of protocols indicating detrimental performance outcomes via static stretching have stretched muscles for greater durations than those used by sports participant's in common pre-competition warm-ups (Avela et al 1999; Behm et al 2001; Cornwell et al 2001 Cramer et al 2004; Fowles 2000; Kokkonen et al 1998; Nelson et al 2001; Pope et al 2000). Furthermore several studies that support the disuse of static stretching involved no aerobic component preceding the stretching (Cornwell 2001; Fowles 2000; Kokkonen et al 1998, Nelson et al 2001). For example stretches were held for 90 seconds per muscle during Kokkonen et al's (1998) investigation, and for as long as 1 hour without any prior aerobic exercise during Nelson et al's (2001) study. While these research designs are necessary to isolate the influence of stretching, the question of whether the apparent decrease in power output reported in these studies is applicable to sports is a stimulating one. Especially given that the typical stretch routines utilised and recommended for youth sports generally last no more than 10-30 seconds per muscle group and are preceded by aerobic exercise (Vigilio 1997; ACSP2000; Holcomb 2000; Martens 2004).

Taylor et al (1990) highlights that muscles and tendons act visco-elastically, implying that the changes in muscle length are directly proportional to the magnitude of the applied load. Thus, it is viable that excessive stretching durations employed in some of the past studies may elicit neural and excessive mechanical force inhibitory mechanisms that are not apparent during typical pre-competition static stretching warm-ups (Knudson et al 2001; Young and Behm 2003; Zakas et al 2006). Recently Zakas (2006) considered the differing consequences of varying stretch durations on youth football players, the study demonstrated that 15 seconds of pre-event static stretch, repeated three times, did not cause significant loss in concentric isokinetic peak torque production. Whereas, a static stretch of 5 min total duration caused significant losses in concentric isokinetic peak torque production. Similar observations were made by Knudson et al (2001), who reported the impact of short duration (3 × 15 s) static stretch had no significant decreases in jump performance compared to a controlled condition. Furthermore, Alpkaya & Koceja (2007) recently cited no significant changes alterations in explosive force production and reaction time following 45 seconds of passive static stretching of the gastrocnemius and soleus muscles (3 × 15 s). Alpkaya et al (2007) concluded their study stating that although more work was necessary the fundamental differences between previous results and theirs was the duration of the applied static stretching. This sentiment is also echoed by Siatras et al (2008) whom recently investigated the acute effect of different static stretching durations (no stretch, 10-s, 20-s, 30-s, and 60-s) on quadriceps isometric and isokinetic peak torque production. The study found significant knee joint flexibility increases and significant isometric and isokinetic peak torque reductions occur only after 30 and 60 seconds of stretching. Siatras et al (2008) concluded by advocating the avoidance of long duration stretching, stating that short duration (10 or 20 seconds) pre- exercise static stretching exercises where ideal for most athletes. However, an argument could be made regarding the relationships between such isolated testing modalities (laboratory isometric and isokinetic dynamometry) used within these studies and the multi joint rapid movements of most sports (discussed in detail below).

2.11.2 Validity of past tests to sports participants

Also noteworthy is the currently lack of evidence involving varying warm up protocols on trained youth and adult performers on physical performance parameters closely related to the actual demands of the subjects own specific sports. Research indicating that pre-activity static stretching is detrimental to performance has often involved slow tasks such as 1 repetition maximum tests and isokinetic contraction (Siatras et al 2008; Avela et al 1999; Behm et al 2001; Fowels 2000; Kokkonen et al 1998; Nelson et al 2001) which are not directly related to multi joint gross movements used during athletic performance. For example, Kokkonen et al (1998) found that a regime of acute static stretching inhibited the 1 repetition maximum lift of both knee extension and flexion using a muscle stretching program of 20 minutes' in duration. More recently Siatras et al (2008) also supported the theory that strength production may be negatively affected after 30 and 60 seconds of static stretching on quadriceps isometric and isokinetic peak torque production. Siatras et al (2008) concluded the study by postulating the avoidance of acute static stretching exercises before any activity demanding maximal force and power output. Murphy & Wilson (1997) however, highlights that such tests of muscle function are severely limited in terms of their reflection of actual athletic performance changes. Knudson et al (2004) recently added to this notion by illustrating that a pre activity static stretching routine made no significant difference on either the speed or the accuracy of an explosive tennis serve, thus raising the question of transferable validity of many of the tests used in the past studies to that of sports participants.

Clearly it is possible that differences in activation patterns and muscle synergies between isolated joint movements and the continually varying high velocity complex multi-joint movements of sports could produce different acute response to stretching. Furthermore, a large extent of the research reporting stretching induced decreases in strength or power has been observed only during concentric type muscle actions (Cramer et al 2004; Cramer et al 2005; Evetovich et al 2003; Marek et al 2005; nelson et al 2001). Whereas most sports are highly dependant on generating rapid switches from eccentric to concentric contraction (Fletcher et al 2004). Moreover, despite the increasing popularity of a dynamic warm-up, several researchers have cited that further research is required on dynamic exercise on the effects of performance that relates to the demands of specific sports (Faigenbaum et al 2006b).

2.11.3 Training status in past studies

Another issue with the i ecological validity of past research in terms of practical sports application is the varying array of subjects used. Few studies have investigated performance related to specific athletic populations (notably team sports). It could be suggested that different athletic populations may have entirely different responses across varying sports and great disparity to sedentary populations, and thus the relevance of some past data may be questionable. For instance, Siatras (2008) recently highlighted that a bout of pre exercise static stretching reduced performance of a previously sedentary population. Whereas Knudson et al (2004) ascribed no difference in performance after static stretching in trained tennis players.

Clearly there is a great complexity of defining the optimum warm up for peak performance. Of course, as already mentioned a number of past studies have highlighted both positive and negative results with athletic populations. However, it is difficult to generalise such results to varying sports and age groups due to differences in the physical maturity of the subjects, training status, training age, requirements of sport and the design of the warm-up protocols (i.e., intensity, volume, time under tension, and choice of exercises). In order to define an ideal warm up more research is required; ideally the requirements of each sport need to be evaluated so that the warm up treatment is consistent with the needs of the athlete.

2.12 Conflicting static stretching evidence

Further conflicting evidence regarding the acute effects of static stretching on performance capabilities has also been observed with several researchers observing no acute effects of stretching on a range of tasks (Alpkaya & Koceja 2007; De veries et al 1963; Knudson 2004; Knudson 2001; Kubo et al 2001; Unick et al 2005; Vetter 2007; Hunter et al 2002; Power et al 2004). For example, Vetter *(*2007) recently demonstrated that a warm-up including static stretching did not negatively effect sprint time. Hunter et al (2002) also reported that stretching appeared to offer no added benefits to drop jump height and had no effect on drop jump technique. Similarly, Power et al (2004) found that jumping performance was not affected after stretching and suggested that jumping activities involving higher reaction forces may benefit from pre event stretching.

Additionally, the chronic effect of static stretching (flexibility training) performed at other times of the workout appears to consistently enhance performance during single joint movements (Guissard & Duchateau 2004; Behm et al 2006; Hortobagy et al 1985; Worrell et al 1994). However, whether these enhanced performance capabilities are translated to improvements in gross athletic performance measures such as sprinting, jumping and agility is less definitive. Studies investigating the chronic effect static stretching on overall athletic performance have utilized many different outcome measures, finding varying results. Beaulieu (1984) observed increases in speed in athletes whom performed long term combined force and static stretching routines compared to athletes who didn't. Dintiman (1964) also attested to an increase in performance through flexibility training citing that after 8 weeks of static stretching ROM and running speed improved significantly compared to a control group. Furthermore several other researchers have also attributed enhancements of athletic performance after long term stretching routines to increased mobility, force, speed and ROM (Hortogagyi et al 1985; Wilson et al 1992; Shrier 1999). Conversely there is also recent evidence to suggest that chronic flexibility training does not initiate improvements in athletic performance in running and jumping tasks (Hunter & Marshall 2002; Behm et al 2006; Bazett-Jones et al 2008). For example recently Bazett-Jones et al (2008) demonstrated that six weeks of a static stretching protocol did not improve sprint and vertical jump performances in track and field athletes.

In terms of ROM several studies have revealed significant improvement with chronic static stretching protocols in both youths (Zakas et al 2002; Medina et al 2007; Nelson & Bandy 2004) and older subjects (Reid & McNair 2004) . For instance, in high-school-aged subjects, Nelson & Bandy (2004) measured hamstring flexibility after a 6-week program of static stretching for 30 seconds, 3 days per week. They found a significant improvement in hamstring flexibility evaluated with the passive knee extension test. More recently, Medina et al (2007) addressed static stretching and ROM in prepubertal child. The study indicated that a full school term (9 months) incorporating static stretching as part of Physical Education classes and extracurricular physical activities significantly increases the ROM of the hamstrings in the prepubertal child. Such studies are particularly noteworthy as recent research indicates that during the school years flexibility decreases (Medina et al 2007).

Thus, although there is a large volume of studies highlighting the detrimental effects of acute pre-event static stretching on performance it could be argued that the use of static stretching may depend on the relative needs of mobility, force, speed and ROM of the subsequent sport. It could be speculated that it is necessary that coaches who are involved with young athletes should emphasize static stretching as a vital part of their development and performance. An individual with limited ROM whose sport or event requires a certain level of flexibility must also weigh these effects against the needs of their activity. Cleary If a young athlete is not flexible enough to move proficiently for their sport, then a acute and chronic protocol of pre exercise bout of stretching might allow a performance enhancement.

2.13 Static and dynamic exercise combined

One area that has received little research is the combination of both static stretching and dynamic exercise as means of pre-event warming up. Given that not all static stretching evidence had been shown to be detrimental and that chronic static stretching may enhance performance it could be argued that the amalgamation of the two procedures could be an ideal procedure. Jones (2002) discusses this premise highlighting that in theory dynamic exercise specific to a sporting event could be used to raise the athlete's core temperature and prepare for the subsequent sports movements, and interspersed short duration static stretching could be used to acutely and chronically increase range of movement. Noteworthy is Rosenbaum et al’s (1995) study that demonstrated 10 minutes of treadmill running after static stretching reversed the reduction in active peak force and rate of force development yet retained the improved stretch-absorbing capacity. Nonetheless for such a protocol to succeed any negative effects from short-duration static stretching would need to be mitigated by the post-use of dynamic exercise. Conversely several studies have highlighted the effects of stretching to be long lasting (Power et al 2004; Fowles & Sale 1997). For example, Fowles & Sale (1997) demonstrated a decrease in voluntary contraction for up to 1 hour poststretch, and Power et al (2004) highlighted the neurological deficit linked to static stretching still being present after 2 hours. Although once again these studies used far longer static stretching durations than typically used by athletes and far less complex movement patterns to measure performance.

To date studies utilising combined static and dynamic exercise warm-ups are sparse. Recently Fletcher & Anness (2007) discovered that stretching, despite being combined with dynamic exercise resulted in an significant increase in sprint time when compared to various other warm-up protocols. Furthermore Winchester et al (2008) cited a 3% decrease in sprint performance of 40 m in collegiate athletes despite having undergone an extensive dynamic warm-up prior to the stretching condition. Noteworthy however is the linear nature of the subjects sprinting task in these studies. It could be argued that the use of static stretching may depend on the relative needs of mobility, force, speed and ROM of the subsequent sport. It could be speculated that in sports where agility, speed and power are factors, ROM may be of higher priority. Coaches who are involved with young athletes may need to emphasize static stretching as a vital part of performance as an individual with limited ROM whose sport or event requires a certain extent of flexibility must also weigh these effects against the needs of their activity.

2.14 Identifying the purpose of the study

Clearly methodological limitations in past research contribute to some of the confusion and disagreements surrounding pre-exercise warm ups. The selection of participants, their training state, warm up and testing procedures may all contribute to the discrepancy of the results. Upon examination it appears that the use of a dynamic exercise protocols like those performed in the above mentioned studies may represent a more effective method of preparing for athletic performance than traditional static stretching. However, more research is needed to solidify this relationship. In addition, insufficient data exists examining a possible deleterious effect of static stretching on the possible gains from using a combination warm up (static and dynamic) prior to physical activity. Furthermore there is currently a dearth of information on the relationship between warm up procedures directly applicable to specific sports populations, with very few of the previous methods having a direct relationship with young athletes in specific sports. Murphy et al (1997) suggests that the effect of interventions or training should be based on changes in the specific population's performance rather than changes in test scores of muscle function. Although a means for testing static stretching, dynamic and combined warm-ups during a competitive youth team game remain elusive maximum benefits could be obtained when the testing stimulus mimics skills and attributes that are transferable to a match situation (Knudson et al 2004).

In view of the fact that, several minutes of low intensity aerobic exercise followed by short-duration (10-30 seconds) static stretching exercises is still recommended by professional organizations and continues to be part of the warm-up protocol for most youth sports (NASPE 2005; Faigenbaum & McFarland 2007b; Alter 2004; ACSP2000; Holcomb 2000; Martens 2004; Vigilio 1997); it would be beneficial to compare the performance outcomes of a typical youth team warm up with a dynamic warm in a sports specific context. Furthermore, given that not all static stretching evidence has been shown to be detrimental and that chronic static stretching may enhance performance the outcome of an amalgamated static and dynamic warm on a specific sporting population would also provide worthwhile results. Consequently, the purpose of this study was to examine the differing acute effects of a typical youth team static stretching warm up with that of a dynamic exercise warm up and a combination (dynamic and static stretching) warm up on the sports specific actions of youth rugby union players; namely speed, agility and muscular power.

2.15 The test variables

The game of Rugby Union is a collision sport requiring high- intensity, intermittent, non continuous exercise (Deutsch et al 1998; Duthie et al 2006). During training and match play, various intensities are involved with many different motor actions performed, such as sprints, starts, jumps, duels, throwing and kicking. The three main physiological characteristics alluded to, that create elite ruby players, are highly developed attributes in speed, agility and muscular strength and power (Deutsch et al 1998; Duthie et al 2006; Gabbett 2005).

Firstly, 20 meters running performance was selected as a measure of assessing speed. Duthie et al (2006) highlights that speed in rugby union is a crucial element regardless of position. 20 meters was chosen as time motion studies have shown that rugby union players during match situations will typically have a sprinting range of 10-20 meters (Deutsch et al 1998). Secondly, the ‘L run’ (Webb et al 1983) was chosen as means of testing agility. Agility during game situations is an essential component, players are required to rapidly accelerate, decelerate, and change direction over short distances or accelerate and sprint to make position (Duthie et al 2006). Meir et al (2001) and Webb et al (1983) state that the ‘L run’ specifically reflects the movement patterns incorporated in rugby union games. Thirdly, the Vertical jump was utilized to assess muscular strength and power (Semenick 1990). Players are required to have high muscular power to perform the tackling, lifting, pushing, and pulling tasks that occur during a match (Meir et al 2001), as well as providing fast play-the-ball speed and leg drive in tackles (Duthie et al 2006). The vertical jump was chosen as efforts depend to a large extent on the maximal strength and power of the neuromuscular system, particularly that of the lower extremities (Deutsch et al 1998).

2.16 Hypothesis

This data, despite its ecological shortcomings will provide external validity to youth rugby, helping to identify the most effective warm-up protocol for optimizing performance. Furthermore as the attributes (speed, agility and muscular power) are common requirements for a variety of similar sports the information generated will be interesting and of value to coaches, young athletes and physical education teachers who typically administer warm up activities. Given that dynamic exercise has been shown to increase performance on a multitude of tasks and the deleterious effect of static stretching in a laboratory setting on skills relying on the rate of force production and peak force generation, one could assume that pre-performance stretching would negatively influence the performance of explosive sports specific activities such as sprinting, jumping and agility runs. The researcher hypothesized that a warm up consisting solely of dynamic exercise would result in superior performance on speed, agility and muscular power in trained youth rugby union players than that of the static stretching and combined warm-up protocol.

CHAPTER 3

METHOD

3.1 Experimental approach to the problem

In this study the researcher wanted to compare the acute effects of three different warm-ups involving static stretching, dynamic exercise and a combination (dynamic and static stretching) protocol on selected performance measures in youth rugby. Using a randomized, counterbalanced, repeated measure experimental design a youth rugby union team performed three different warm-up protocols in a random order with sessions administered at least 3 days apart. All warm-up protocols began with low intensity aerobic exercise followed by either a static stretching protocol, dynamic exercises protocol or a combination protocol. After each warm-up routine, participants performed the selected tests designed to measure muscular power, speed, and agility. In order to control for learning effects that could result from repeated testing, the researcher used a counterbalancing technique in which the order of the warm-up protocols was randomly assigned. Each subject completed all test with a dynamic warm-up protocol, static warm up protocol and combination protocol within 30 days. This design allowed the researcher to assess performance individually after each warm-up treatment and to carefully monitor the response of each participant to study procedures. All testing sessions were performed with identical equipment, technique, positioning and order. Testing occurred at the same time each session (6.30pm).

3.2 Participants

Twenty six boys from a local amateur club originally volunteered to take part in this study. Six boys did not complete all study procedures because of a scheduling conflict.

No participant withdrew because of injury or other adverse experiences. The final sample consisted of 20 participants. The mean ± *SD* for age, height, and body mass of participants who completed all study procedures was 12.4 ± 0.7years, 155.6 ± 9.1 cm, and 46.2 ± 12.8 kg, respectively. All participants in the study were aged between 12-13 (the official age group allowed to play full contact rugby), took part in regularly (at least 3 times a week) sports activities, had been playing rugby union for at least 1 year and had previous experience performing both dynamic exercise and static stretching, and completed a health screen before participation. The methods and procedures used in this study were approved by the University of Chester and the rugby club (Appendix K). All participants were informed of all procedures before attending the first session and informed consent was obtained from all participants and their parents (appendix G, H & I).

3.3 Warm-up Protocols

Preceding data collection, all subjects participated in an introductory session during which correct form and technique of each warm-up protocol and performance test were practiced and evaluated. This introductory phase was designed to decrease the impact of any learning effects caused solely by the mechanics of performing the investigation protocols.

Each warm-up treatment lasted around 12 min. The first 5 minutes of both protocols consisted of 2 min of brisk walking and 3 min of jogging at a self selected comfortable pace (approximately 1,000 metres around a rugby pitch). Subjects warmed up in groups of 2, with the researcher and team coach demonstrating the proper technique for each movement during every warm-up period. All study procedures took place at the start of the team's training session, participants were asked not to participate in any moderate to high intensity physical activity before each session.

3.3.1 Static Stretching protocol

The static stretching protocol took place immediately after the initial warm up and consisted of 6 static stretches for the major muscle groups (Appendix A). More in depth descriptions of each stretch are available elsewhere (Anderson et al 2000). Subjects performed each stretch in a controlled manner with correct body alignment. Subjects held each stretch for 15 seconds at a point of mild discomfort, followed by a rest for 3 seconds, then repeated once more. The stretching protocol used in this study was consistent with general flexibility recommendations for children and representative of a typical youth team warm up (NASPE 2005; Faigenbaum & McFarland 2007b; Alter 2004; ACSP2000; Holcomb 2000; Martens 2004; Vigilio 1997). The design of this protocol did not allow the researcher to isolate the effects of static stretching on test performance, due to the fact it was considered inappropriate for youth to perform static stretching in a rested state (Fagenbaum et al 2006; Siatras et al 2003).

3.3.2 Dynamic exercise warm up protocol

The dynamic exercise protocol took place immediately after the initial warm up and consisted of 10 dynamic exercises that progressed from low to high intensity (appendix B). Subjects performed each dynamic exercise for a distance of 15 metres, rested 10 seconds, and then repeated the same exercise as they returned to the starting point. Throughout the dynamic warm up subjects were repeatedly instructed to maintain correct technique. The dynamic warm-up protocol was designed to replicate a dynamic warm-up protocol advocated for athletes by strength and conditioning specialists (Fredrick et al 2001; Mann 1999; Ruteledge and Faccioni 2001).

3.3.3 Combined dynamic and static stretching exercise warm-up

The combined dynamic and static stretching exercise protocol will take place immediately after the initial warm up and consist of 5 dynamic exercises that progressed from low to high intensity interspersed with 5 static stretches for the major muscle groups(appendix C). Subjects performed each dynamic exercise for a distance of 15 metres; upon reaching 15 meters a static stretch was then performed. Subjects were then advised to hold each stretch for 15 seconds at a point of mild discomfort. Upon completing the static stretch the same dynamic exercise was repeated as they returned to the starting point. The design of this combined dynamic exercise and static stretching protocol was to compare the effects of an amalgumated static and dynamic warm up on performance.

3.4 Performance Tests

Following the completion of each of the warm up protocols, subjects walked at a comfortable pace for 2 minutes prior to testing (as suggested by Faigenbaum 2006a). Power, speed, and agility were then tested using the vertical jump, 20 metre sprint and 'L-run' following standardized protocols (detailed descriptions of testing protocols are attached in appendices D,E and F). The testing procedures used in this study were designed to replicate the skills and movement patterns used in rugby union.The best score for three trials for each test was recorded to the nearest 0.5 cm using a Vertec jump device (Hilliard, OH), or .01 s using the electronic Speed Trap II Timing System (Brower Timing Systems, Draper, UT). Once subjects completed all procedures on a given fitness test they immdiately progressing to the next test. The same researchers tested the same subjects following the same test order (vertical jump, L- run and 20 meters sprint), which was based on the duration of each test item and the muscle groups involved. All subjects completed the test battery in approximately 25 to 30 minutes. All tests were conducted in indoors, in dry conditions wearing appropriate training clothing.

3.4.1 Vertical jump

The Vertical jump was chosen as a measure of muscular power (appendix D). Semenick (1990) showed the vertical jump test to be a valid and reliable test for measure of muscular power and strength. Standardized protocols for testing were followed according to methods previously described (Semenick 1990). The vertical jump was measured using a Vertec jump device (Hilliard, OH). Subjects were instructed to stand with feet flat on the ground, extend their arm and mark a standing reach height. After assuming a crouch position, each subject was then instructed to spring upward and touch the device at the highest possible point. Vertical jump height score was calculated as the distance from the highest point reached during standing and the highest point reached during the vertical jump.

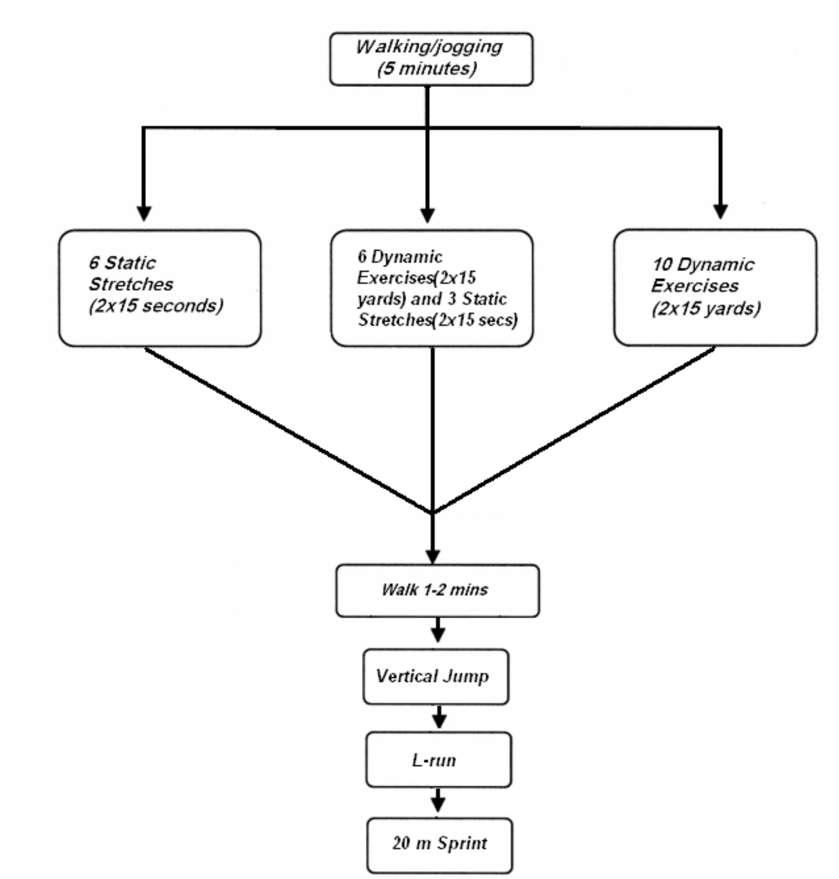
3.4.2 The 'L run'

The agility of players was evaluated using the ''L run'' (appendix E). Webb et al (1983) showed the L run test to be a valid and reliable test for agility. The movements utilised during the L run have been stated to reflect the movement patterns of rugby union (Meir et al 1993; Webb et al 1983). Standardized protocols for testing were followed according to methods previously described (Webb et al 1983). Three cones were utilised approximately 1 m in height, placed 5 m apart in the shape of an L. From a standing start, dominant foot forward subjects ran forward 5 m turned to their left, ran forward 5 m, turned 180 degrees and followed the same course to return to the finish line. Subjects were instructed to run as quickly as possible throughout.

3.4.3 20 meters sprint

20 metres sprint time was chosen as a measure of the subjects speed (appendix F). Deutsch et al (1998) stated that the mean sprint distance of rugby union players in match situations is 20 metres. This distance was also utilised in a recent studies by Fletcher et al (2004) and Walsh et al (2007) as a measure of testing performance of sport specific actions in rugby union players. Standardized protocols for testing were followed according to methods previously described (Fletcher et al 2004). Subjects were instructed to run as quickly as possible along the 20- m distance from a standing start, dominant foot forward. A summary of testing procedures is shown in figure 1.

Figure 1: Order of testing procedures



3.5 Statistical Analysis

A one-way repeated-measures analysis of variance design (× 3) was used to analyze the data. Differences between each test and among each warm-up protocol (pre, mid, post) were investigated. A value of $P \leq 0.05$ was considered statistically significant for all comparisons. 3 x paired samples T-tests were then conducted to analyze differences among the Vertical jump, twenty meters sprint, and 'L run' after the dynamic exercise, static stretching and combination warm-up protocols with a Bonferroni post hoc analysis used for multiple comparisons (statistical significance was set at $p < 0.017$). All analysis was carried out using the Statistical Package for the Social Sciences version 11.0 (SPSS, Inc. Chicargo, IL).

CHAPTER 4

RESULTS

4.1 Summary of results

The mean and standard deviation highlighted in table 1 illustrate that a greater performance on all tests was seen when the test was preceded by the dynamic warm-up protocol. Mean Vertical jump scores were 28.03 ± 4.02, 30.18 ± 4.24 and 27.8 ± 4.03 after the static stretching, dynamic exercise and combination (static and dynamic) warm ups respectively. Mean L run times (sec) were 8.18 ± 0.55, 7.86 ± 0.61 and 8.16 ± 0.53 after the static stretching, dynamic exercise and combination warm ups respectively. Like wise, mean 20 meters sprint times were 5.41 ± 0.40, 5.14 ± 0.36 and 5.36 ± 0.35 after the static stretching, dynamic exercise and combination warm ups respectively

Table 1: Test performance after two different warm-up protocols: mean ± SD

Test	***Static***	***Dynamic***	***Combination***
Vertical Jump	***28.03 ± 4.02***	***30.18 ± 4.24***	***27.8 ± 4.03***
'L run'	**8.18 ± *0.55***	**7.86 ± *0.61***	**8.16 ± *0.53***
20 meters sprint	***5.41 ± 0.40***	***5.14 ± 0.36***	***5.36 ± 0.35***

4.1.1 Vertical Jump

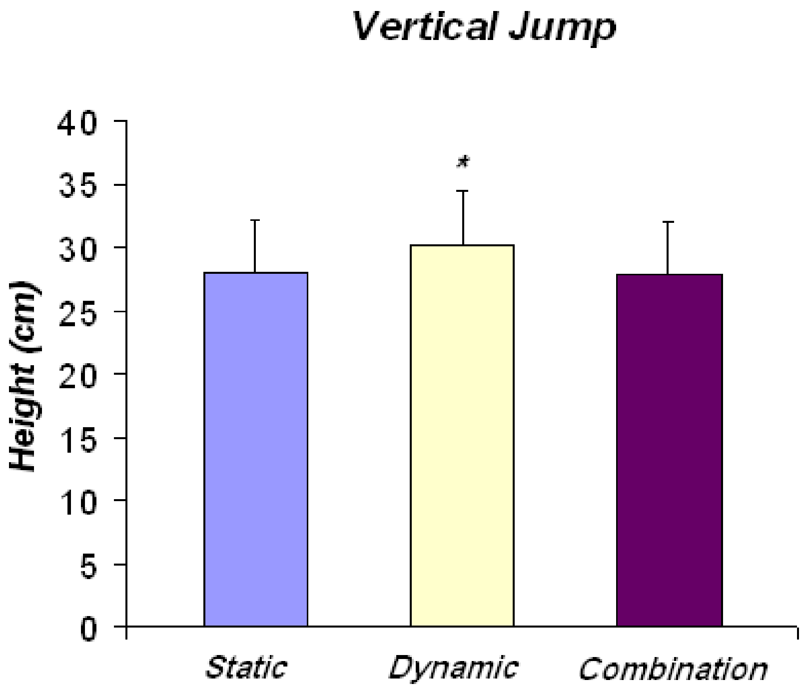


Figure 2: Mean vertical jump results for static, dynamic and combined protocols.

Figure 2 illustrates the differences between the mean vertical jump scores among the static, dynamic and combined protocols. Results revealed performance on the vertical jump was significantly greater after the dynamic warm up protocol* than after both static stretching [t (19) = -4.626, p=.000] and combination protocols [t (19) = 3.824, p=.001]. Mean and standard deviation of the vertical jump preceding the dynamic exercise protocol were 30.18 ± 4.24, as compared to 28.03 ± 4.02 and 27.8 ± 4.03 for the static and combination protocols respectively. Mean performance after the dynamic protocol increased by 7.7 % in comparison to the static stretching protocol. Similarly mean performance after the dynamic protocol increased by 8.6% in comparison to the combination protocol. No significant differences between static stretching and combination warm-up trials were observed for Vertical jump (*p*= .454).

4.1.2 L run

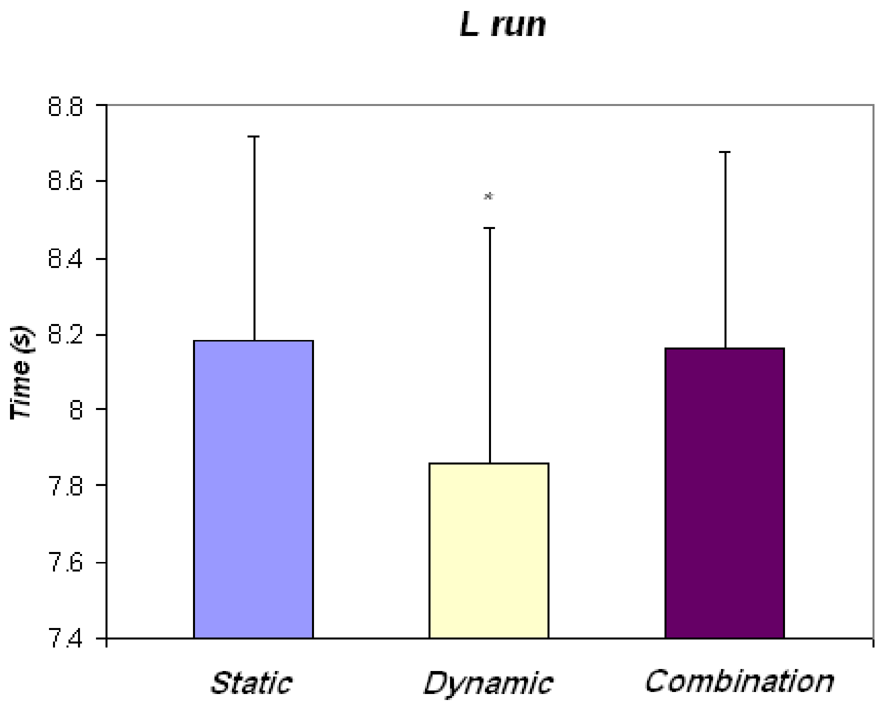


Figure 3: Mean 'L run' time for static, dynamic and combined protocols.

Figure 3 illustrates the differences between the mean L run scores among the static, dynamic and combined protocols. Results revealed performance on the L run was significantly greater after the dynamic warm up protocol* than after both static stretching [*t* (19) = 3.579, *p*= .002] and combination protocols [*t* (19),= -3.111, *p*= .006]. Mean and standard deviation of the L run preceding the dynamic exercise protocol were 7.86 ± *0.61*, as compared to 8.18 ± *0.55* and 8.16 ± *0.53* for the static and combination protocols respectively. Mean performance after the dynamic protocol increased by 4.1%

in comparison to the static stretching protocol; similarly mean performance after the dynamic protocol increased by 3.8% in comparison to the combination protocol. No significant differences between static stretching and combination warm-up trials were observed for Vertical jump (*p*= .579).

4.1.3 20 Meter sprint

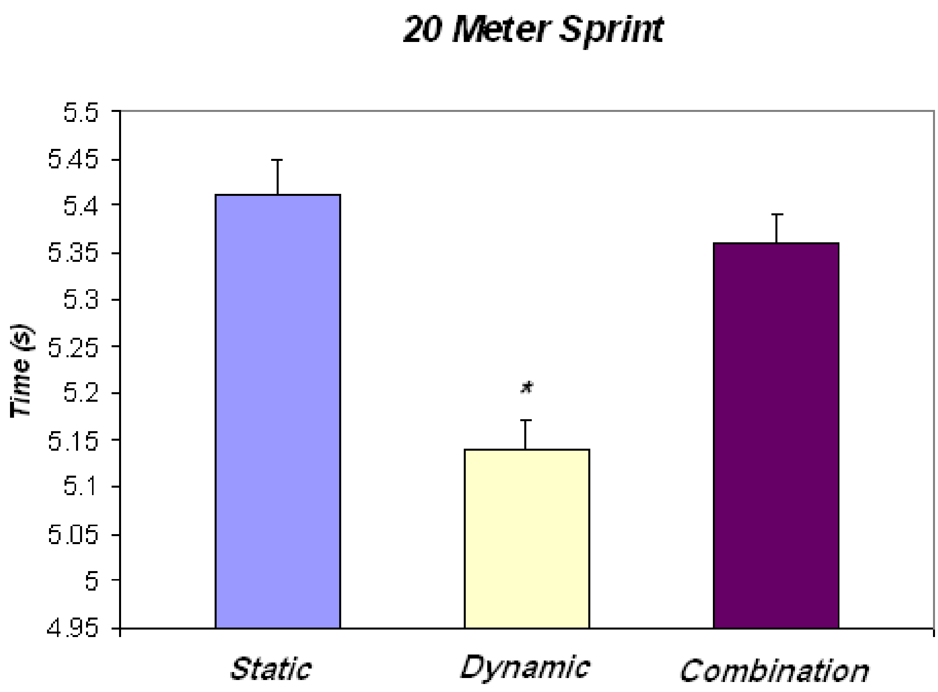


Figure 4: Mean 20 meter sprint time for static, dynamic and combined protocols.

Figure 4 illustrates the differences between the mean 20 meter sprint times among the static, dynamic and combined protocols. Results revealed performance on the 20 meter sprint was significantly greater after the dynamic warm up protocol* than after the static stretching protocol [t (19) = 2.668, p = .015]. No significant difference were observed between the combination and dynamic protocol (p= .035).However, trends towards significance were observed for the combination warm up protocol. Mean and standard deviation of the 20 meter sprint preceding the dynamic exercise protocol was 5.14 ± *0.36*, as compared to 5.41 ± *0.40* and *5.36* ± *0.35* for the static and combination protocols respectively. Mean performance after the dynamic protocol increased by 5.3% in comparison to the static stretching protocol; similarly mean performance after the dynamic protocol increased by 4.3 % in comparison to the combination protocol. No significant differences between static stretching and combination warm-up trials were observed for Vertical jump (p= .465).

CHAPTER 5

DISCUSSION

This study investigated the acute effects of dynamic, static stretching and combination warm-ups on speed, agility and muscular power in trained youth rugby union players. The main findings of the study were that a warm-up protocol that included dynamic exercise resulted in superior performance on both the vertical jump and 'L run' as compared with a warm up protocol consisting of static stretching and combined static and dynamic stretching. Performance on the 20 meters sprint was also significantly greater after the dynamic protocol than after the static but not the combination protocol, however trends towards significance were also observed for the combination warm up protocol. Results revealed that dynamic warm-up protocol enhanced mean performance in vertical jump, 'L run' and 20 meter sprint compared to the static stretching protocol by 7.7%, 4.1%, and 5.3%, respectively. Similarly, in comparison to the combination warm up the dynamic protocol improved mean performance by 8.6%, 3.8% and 4.3%(not significant). Consequently, the data supports the hypothesis that the dynamic protocol would result in superior performance on speed, agility and muscular power in trained youth rugby union players.

5.1 Similar findings

To my knowledge, no other authors have examined the effects of static, dynamic and combination warm-up protocols, on speed, agility and muscular power performance in trained youth rugby union players. However, the results are consistent with other investigations that found performance enhancement across various tasks via dynamic warm-up protocols in comparison to static stretching protocols in adults (Burkett et al

2005; Fletcher et al 2004; Little et al 2006; Mcmillian 2006) and youths (Faigenbaum et al 2005; Fagenbaum et al 2006a; Faigenbaum et al 2006b; Siatras 2003). Specifically, Faigenbaum et al (2005) whom illustrated that power and agility performance of children by means of vertical jump, long jump and shuttle run increased 6.5%, 1.9% and 2.6%, respectively following a dynamic exercise warm up compared to static stretching protocol. Similar findings were also reported by McMillian et al (2006) who examined the acute effects of warm-up protocols in adult military cadets on power and agility performance utilising the 'T-drill', Medicine ball throw and 5 step jump performance. McMillian et al (2006) cites that the dynamic protocol conferred a modest performance enhancement for all 3 measures. Fagenbaum et al (2006a) also noted similar findings in teenage athletes where performance in power, strength and speed via vertical jump, seated medicine-ball toss, and 10 yard sprint improved by 3.6%, 2.3% and 2.5%, respectively after a warm-up protocol consisting of dynamic exercise as compared to a protocol with static stretching (Fagenbaum et al 2006a). Furthermore, the results of this study are consistent with those recently cited by Fletcher *&* Anness *(*2007) and Winchester et al (2008) whom both allude to significant decreases in performance when combining stretching with dynamic exercise.

5.2 Dynamic exercise

Thus the current study data indicates that a warm-up consisting of dynamic exercise might be more beneficial than a typical youth team warm-up of 5 minutes of low to moderate intensity followed by short duration static stretching for preparing trained youth rugby union players for performance. Although the exact reasoning for performance enhancement via a dynamic exercise warm up are currently elusive, a number of explanations have been postulated. Dynamic exercise might enhance neuromuscular function creating a more favourable environment for performance by increasing the rate of force development via a phenomenon known as 'postactivation potentiation' [PAP] (Sale 2002). Golhofer et al (1988) and Hamada et al (2000) both demonstrated that PAP appears to have a great affect on fast-twitch muscle fibers. Therefore it could be suggested that the dynamic exercises used in the current study somehow enhanced the excitability of the fast-twitch units and therefore prepared these units to play a greater and more significant role during the explosive sprinting, jumping and acceleration activities. Similar proposals have been made by other researchers who have reported that a dynamic exercise warm-up may facilitate the function of the neuromuscular system through PAP (Faigenbaum et al 2005; Faigenbaum et al 2006a).No tests on neuromuscular activation were conducted in the current investigation.

The positive changes in performance from the dynamic exercise protocol in the present study may have also stemmed from facilitated motor control via the more specific movement patterns incorporated to the subsequent task than that of the static stretching warm up (Clark 2000; Fletcher et al 2004;Young et al 2003). Young et al (2003) demonstrated that the rehearsal of practice jumps immediately before a concentric jump and a drop jump resulted in significantly greater performance than a warm-up without the practice jump. Therefore it is possible that the dynamic skipping and jumping activities incorporated in the dynamic exercise warm-up in the current study may have opened up specific neural pathways to facilitate motor unit activation thereby enhancing the readiness of the neuromuscular system for the vertical jump task. Likewise, proprioception is an important element for sprinting, accelerating and rapidly changing direction, predominantly for pre-activation to aid the rapid switch from eccentric to concentric contraction (Refshauge and Gass 2004). One could speculate that the dynamic exercise protocol used in the present study, which incorporated rapid switches of eccentric to concentric contraction, allowed a similar rehearsal of the movement coordination patterns to the vertical jump, 20 meter sprint and the ‘L run’, allowing muscles to be excited quicker and earlier and thus enhancing performance .

Additionally there is the possibility that significant improvements on performance through the dynamic warm-up may have stemmed from the greater increase in core temperature than that of the static stretching protocol. Increases in core temperature have been reported to increase the transmission rate of nerve impulses (Karvonen 1992; Sherlock et al 1985), decrease the stiffness of muscles and joints (Wright et al 1961; Butchthal et al 1944) change the force- velocity relationship (Binkhorst et al 1977; Ranatunga 1987) and to increase blood flow, glycogenolysis, glycolysis and high energy phosphate degradation (Edwards et al 1972; Febbraio et al 1996). Collectively this increase in core temperature could potentially augmented performance by encouraging muscle contractions to be more rapid and forceful thus enhancing the subsequent performance. Core temperature was not recorded in this study; however given that after the initial warm up period static stretching was performed in a slow controlled manner, and the dynamic protocol developed from low to high intensity, core temperature increases were highly likely to have been greater after the dynamic protocol than both the combined and static protocols. Thus, it could be speculated that the improvements in performance may have stemmed form either the effects of the dynamic exercise per se, improved neural function or additional metabolic costs or the amalgamation of all of the above. Additionally a case could be made for the motivational aspects of the warm ups used. Clearly, If the warm-up is slow and monotonous (e.g., walking or jogging followed by static stretching), then the motivation be may be less than expected.

5.3 Static stretching

In contrast to the benefits of a dynamic exercise warm up, there are a number of reasons postulated why a static stretching protocol may decrease subsequent performance relative to dynamic and combination protocols. The decrease in performance in the present study with the use of static stretching provides supporting evidence for a number of studies in both youth (Faigenbaum et al 2005; Faigenbaum et al 2006a; Faigenbaum 2006b Mcneal et al 2003; Siatras et al 2003) and adult subjects (Church et al 2001; Behm et al 2001; Evetovich et al 2003; Fowles et al 2000; Kokkonen et al 1998; Nelson et al 2001; Young and Elliott 2001). The exact mechanisms responsible for a reduction in performance following an acute bout of static stretching are currently elusive. Researchers have alluded to several mechanical or/and neuromuscular mechanisms for the negative impacts of various pre activity static stretching protocols.

Firstly, a number of studies have proposed that static stretching reduces neural activation for preceding task (Hunter et al 2004; Gandevia 2001), with static stretching inducing a proportion of motor units into a fatigued state prior to the onset of the task (Hunter et al 2004). As neural activity was not measured in this study the effect on performance is purely speculative. However studies addressing neural inhibition have indicated that neurological fatigue is caused by a reduction in excitatory inputs (Hunter et al 2004; Gandevia 2001). Adam et al (2003) highlights that a decrease in excitation is compensated for by the increasing recruitment of new motor units, with the initial and the subsequent motor units complying to a specific and unchangeable pattern. Through electromyography and twitch interpolation techniques several studies have found that pre-event stretching causes a reduction in muscle activation (Fowles et al 2000; Behm et al 2001). Therefore, it seems viable although only speculative that the static stretching protocol in the current study may have induced a proportion of motor units into a fatigued state prior to the onset of the task resulting in a greater activation rate and a decrease pool of motor units available for activation.

In addition, a widely held rationale suggested by investigators responsible for the decease in performance following static stretching is a reduction in active or passive stiffness in the musculotendinous unit following the stretching (Kubo et al 2001; Wilson et al 1994; Kokhonen et al 1998). Kubo et al (2001) suggests that stretching may change tendon structure, increasing the compliance between muscle and skeletal system. Potentially such an increased 'slack' in the musculotendinous unit via the static stretching protocol used in this study may have placed the contractile elements in a position that is less than optimal for generating force transmission form muscle to the skeletal system for the subsequent tasks. Conversely, the dynamic protocol may have enlisted a stiffer musculotendinous unit, enhancing contractile component force production by enabling more favorable length and velocity conditions.

5.4 Static and dynamic exercise combined

Authors have previously advocated the use of a warm up that combines both short duration static stretching and dynamic exercise as any negative effects from the stretching would be mitigated by the post-use of the dynamic exercises (Jones 2002). Notably however the combination of a static and dynamic protocol used in his study appears to have minimal effects on performance. Results highlighted that performance on all tests, except the 20 meters sprint, were significantly greater after the dynamic warm up protocol than after both static stretching and combination protocols. No significant differences between static stretching and combination warm-up trials were observed for Vertical jump, 'L run' or 20 meters sprint. Results in the 20 meters sprint however, were significantly greater after the dynamic protocol than after the static but not the combination protocol. On the other hand, performance for the combination warm up protocol in the 20 meters sprint showed trends towards significance with mean performance being decreased by 4.1% in comparison to the dynamic warm up.

Interestingly then, combining static stretching and dynamic exercise prior to the tests had very little effect on performance over dynamic exercise alone. As previously stated the phenomenon of the dynamic warm-up has been linked to the rehearsal of specific movement patterns, helping proprioception and preactivation, allowing an optimum switch from the eccentric to the concentric muscle contraction required to facilitate performance. Whereas, static stretching seems to have the opposite effect, by adversely affecting performance due to an increases in musculotendinous compliance and/or reduced neural activation following the stretch. Studies have illustrated that the effects of static stretching have been shown to be long lasting. For example, Fowles & Sale (1997) demonstrated a decrease in voluntary contraction for up to 1 hour poststretch, with the neurological deficit linked to static stretching still being present after 2 hours (Power et al 2004). Although these studies used far longer hold times then the present study, they also used far less complex movement patterns to measure performance. Therefore, it is likely that in the present study the static stretching procedure, within the combination warm up, elicited decreases in motoneuron excitability and/or increased the musculotendinous unit leading to a increased muscle compliance and reduced efficiency. Fletcher *&* Anness *(*2007) and Winchester et al (2008)both found similar conclusions discovering that stretching, despite being combined with dynamic exercise lead to a significant increase in sprint time in comparison to dynamic protocols alone.

5.5 Sports application- Static stretching time length

Many past studies indicating that pre- activity static stretching is detrimental to performance have used prolonged stretching protocols, not representative of commonly employed stretching routines during warm-ups. For instance, Cramer et al. (2004) and Nelson et al. (2001) used four different static stretching exercises for a total static stretching time of 15 or 16 min. Furthermore, in a number of studies that observed performance decreases the static stretching protocols used were not preceded by aerobic procedures or sub-maximal exercise (Cornwell 2001; Fowles 2000; Kokkonen et al 1998, Nelson et al 2001). Recent studies comparing shorter static stretching periods with prolonged stretch periods and controlled groups have argued that a shorter stretching (e.g. 3 × 15 s) period results in no performance decrements (Knudson et al 2001; Young et al 2003 ;Zakas et al 2006). On the contrary, the present study utilised a static stretching protocol designed to represent a typical youth team warm-up, incorporating both short-duration (2 x 15 seconds) static stretching and a preceding aerobic component, with results indicating a significantly reduction performance in comparison to the dynamic warm-up. As there was no control group in the present study it is not known to what degree the static stretching protocol may have reduced performance or to what extent the dynamic exercise warm up may have increased performance. However, the study provides evidence that a typical youth team warm-up involving short duration static stretching as advocated by professional organizations (ACSP2000; Holcomb 2000; Martens 2004; Vigilio 1997) may be suboptimal for maximizing youth team performance in comparison to a more dynamic protocol.

5.6 Sports specific

Past research on both dynamic and static warm up protocols has often involved tasks that are not readably transferable to sports participants. For example, performance decrements following protocols have often involved slow tasks such as 1 repetition maximum tests and isokinetic contraction contraction (Avela et al 1999; Behm et al 2001; Fowels 2000; Kokkonen et al 1998; Nelson et al 2001). Furthermore a large extent of the research reporting stretching induced decreases in strength or power has been observed only during concentric type muscle actions (Cramer et al 2004; Cramer et al 2005; Evetovich et al 2003; Marek et al 2005; nelson et al 2001). The present study however utilized tasks specific to the participant's sport, such as the 'L run' (Webb et al 1983) which involved high velocity, complex multi-joint movements, dependant on generating rapid switches from eccentric to concentric contraction. Given that the dynamic protocol resulted in a significant performance increase in the 'L run' and the 20 meter sprint over the static protocol, it appears that complex sports specific motor-performance skills may also be affected, either positively or negatively, by the design of the warm-up.

5.7 Implication of findings

The findings of the present study provide provocative evidence that a typical youth team pre-activity warm up, that includes short duration static stretching may be suboptimal for maximizing performance and a more dynamic warm-up may provide a significant performance enhancement in trained youth rugby union players. Furthermore the inclusion of static stretching to a dynamic warm up seems to offer little increased benefit to the athlete's performance beyond that offered by dynamic exercise alone. Although the ecological validity of these results may be questionable they provide external validity to youth rugby and to youth sports of a similar nature (e.g. rugby league, American football etc). In the present study, as a whole, agility and muscular power increased by an average of 5.7% after the dynamic exercise warm-up treatments in comparison to that of the static stretching warm-up, and 5.6% compared to the combination warm up. Faigenbaum et al (2006a) states that as little as a 1 % change in performance levels can have a hugely significant impact on sporting events at any age, which highlights the practical significance of the present study. This is not to say that static stretching should be eliminated completely from a youth rugby teams training program, or other youth sports programs, as chronic improvements in flexibility can be of a high priority to performance in some activities (Shrier 1999; Beaulieu 1984). Rather, that the coaches and performers should consider the potential impact of pre-event treatments on performance.

5.8 Limitations

The following factors should be considered when interpreting the results of the present study. Firstly, the study has no control condition with which to compare the static, dynamic and combination warm-up treatments because it is considered inappropriate for youth performers to participate in physical activity in a completely rested state (Fagenbaum et al 2006a; Siatras et al 2003). Secondly, no physiological or neurological parameters of the warm up protocols were established in the study. In addition, the present study investigated the acute responses to different warm-up protocols in trained youth rugby union players. Therefore, the results should not be generalized to every level of rugby union and sedentary populations as an individual’s training level may affect the response aspects of the warm up (e.g. Chiu et al 2003).

5.9 Future research

Future research should investigate the acute and chronic effects of different dynamic warm-up treatments on performance in varying youth sports. There is a further need to investigate the interaction between dynamic and static stretching components and the impact of varying the warm-up duration, intensity, recovery time and fatigue on performance. Further research is also required to attend to factors such as sports specificity, injury prevention, environmental conditions and psychosocial factors of performance. Ideally the requirements of each sport need to be evaluated so that the warm up treatment is consistent with the needs of the athlete. Additionally research is needed to examine the precise underlying physiological and/or neurological mechanisms that may explain the performance-enhancing/reducing effects of pre-event dynamic exercise and static stretching. This research will lead to improved methods of preparing youth and adults for exercise and sport.

CHAPTER 6

CONCLUSION

The results of the present study suggest that dynamic exercise warm up might be more beneficial for preparing trained youth rugby union players for performance than a typical static stretching warm-up involving short duration static stretching or a combination warm up involving short duration static stretching interspersed with dynamic exercise. Results revealed that a warm-up protocol that included dynamic exercise resulted in superior performance on both the vertical jump and ‘L run’ as compared with a warm up protocol with static stretching and combined static and dynamic stretching. Performance on the 20 meters sprint was also significantly greater after the dynamic protocol than after the static but not the combination protocol. The reasons for the positive increases in performance brought by the dynamic warm up are not clear. The performance benefits via the dynamic warm up may stem from improved neural function from rehearsal of specific movements, PAP or increased core temperature and blood flow. Conversely, that static stretching and combined protocol may have adversely affected performance due to an increase in musculotendinous compliance or reduces neural activation following the stretch. No physiological or neurological parameters were tested in the study.

At present, short-duration static stretching exercises are recommended by professional organizations and continue to be part of the warm-up protocol for youth sports. The study provides evidence that a typical youth team warm up involving short duration static stretching or a combination warm up protocol involving static and dynamic exercise may be suboptimal for maximizing youth team performance in comparison to a dynamic protocol alone. These results might prove useful to youth coaches and youth performers, who want to increase performance in rugby union or similar youth sports. Youth coaches and physical education teachers that typically utilize static stretching protocols should consider the potential value of pre-event dynamic exercise warm ups.

6.1 Practical applications

Given that convincing scientific evidence supporting the injury-reducing and performance-enhancing potential of static stretching is presently lacking (Gleim et al 1997; Herbert et al 2002; Pope et al 2000; Shrier 1999) and the chronic effect of static stretching may offer a performance enhancement (Beaulieu 1984;Shrier 1999) it would be appropriate to suggest that youth rugby union players should perform dynamic exercises during the warm-up period and static stretching during the cool down period. This notion is also supported by previous authors (Faigenbaum et al 2006b; Fletcher et al 2005) and advocated by strength and conditioning specialists (Fredrick et al 2001; Mann 1999; Ruteledge and Faccioni 2001).

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Appendix A

STATIC STRETCHING EXERCISES

The static stretching protocol will take place immediately after the initial warm up and consisted of six static stretches for the major muscle groups. Subjects will hold each stretch for 15 seconds at a point of mild discomfort, followed by a rest for three seconds, then repeated once more(appendix C) . The stretching protocol used in the study is designed to replicate and be consistent with general flexibility recommendations for children and representative of a typical youth team warm up (ACSP2000; Holcomb 2000; Martens 2004; Vigilio 1997).

1. Quadriceps stretch.

In a standing position with an erect spine, bend one knee and bring heel towards buttocks while holding the foot with hand.

2. Hamstring stretch.

In a standing position cross the right foot in front of the left, slowly lower the forehead towards the right knee by bending at the waist. Both knees are slightly bent and arms are straight on either side of the forward leg (changing to the opposite leg on completion).

3. Calf stretch.

In a standing position with feet staggered about 2 or 3 feet from a wall, lean against the wall with both hands, keeping the back leg straight and the front leg slightly bent.

4. Bent-over toe raise.

Starting from a standing position with the heel of one foot slightly in front of the toes of the other foot, dorsiflex the front foot towards shin while leaning downward with the upper body.

5. Adductor stretch.

In a seated position with an erect spine, touch soles of feet together, bend knees, and allow knees to drop.

6. Hip rotator stretch.

In a supine position, cross one leg over the other forming a figure 4, and flex hips to or past 90° by pulling on the uncrossed leg.

Appendix B

DYNAMIC EXERCISE WARM-UP

The dynamic exercise protocol will take place immediately after the initial warm up and consisted of 10 dynamic exercises that progressed from low to high intensity(appendix D). The dynamic warm-up protocol will be designed to replicate a dynamic warm-up protocol advocated for athletes by strength and conditioning specialists (Fredrick et al 2001; Mann 1999; Ruteledge and Faccioni 2001). Subjects will perform each dynamic exercise for a distance of 15 metres, rested 10 seconds, and then repeated the same exercise as they returned to the starting point.

1. High-knee walk.

Whilst walking, lift knee towards chest, raise up body on toes, and swing arms alternately. Concentrate action on extending the stepping leg and getting up on the toes.

2. Straight leg march.

Whilst walking, extended both arms in front of body at shoulder height, lift one extended leg towards hands then return to starting position before repeating with other leg.

3. Lunge walks.

Lunging forward with alternating legs while keeping torso upright.

4. Hand walk.

With hands and feet on the ground and limbs extended, walk feet towards hands while keeping legs extended then walk hands forward while keeping limbs extended.

5. Backward lunge.

Move backwards by reaching each leg as far back as possible, keeping torso upright.

6. High-knee skip.

While skipping lift knees high, emphasize height and rhythm with arm action.

7. Lateral shuffle.

Move laterally rapidly without crossing feet, keeping torso upright.

8. Back pedal. While keeping feet under hips, take small steps to move backwards rapidly, concentrating on the pushing leg extension action.

9. Heel-ups.

Rapidly kick heels towards buttocks while moving forward, keeping torso upright.

10. High-knee run.

While moving forwards quickly, emphasize knee lift and arm swing, keeping torso upright.

Appendix C

COMBINED DYNAMIC AND STATIC STRETCHING EXERCISE WARM-UP

The combined dynamic and static stretching exercise protocol will take place immediately after the initial warm up and consist of 5 dynamic exercises that progressed from low to high intensity interspersed with 5 static stretches for the major muscle groups(appendix E). Subjects will perform each dynamic exercise for a distance of 15 metres; upon reaching 15 meters a static stretch will then be performed. Subjects will be advised to hold each stretch for 15 seconds at a point of mild discomfort. Upon completing the static stretch the same dynamic exercise will be repeated as they returned to the starting point. The design of the combined dynamic exercise and static stretching protocol is to compare the effects of interspersed static and dynamic protocols on performance.

1. High-knee walk. (DYNAMIC) Whilst walking, lift knee towards chest, raise up body on toes, and swing arms alternately. Concentrate action on extending the stepping leg and getting up on the toes.

2. Quadriceps stretch.(STATIC)
In a standing position with an erect spine, bend one knee and bring heel towards buttocks while holding the foot with hand.

3. Straight leg march.(DYNAMIC)
Whilst walking, extended both arms in front of body at shoulder height, lift one extended leg towards hands then return to starting position before repeating with other leg.

4. Hamstring stretch.(STATIC)
In a standing position cross the right foot in front of the left, slowly lower the forehead towards the right knee by bending at the waist. Both knees are slightly bent and arms are straight on either side of the forward leg (changing to the opposite leg on completion).

5. Lunge walks.(DYNAMIC)
Lunging forward with alternating legs while keeping torso upright.

6. Calf stretch. (STATIC)
In a standing position with feet staggered about 2 or 3 feet from a wall, lean against the wall with both hands, keeping the back leg straight and the front leg slightly bent.

7. Lateral shuffle.(DYNAMIC)
Move laterally rapidly without crossing feet, keeping torso upright.

8. Bent-over toe raise. (STATIC)
Starting from a standing position with the heel of one foot slightly in front of the toes of the other foot, dorsiflex the front foot towards shin while leaning downward with the upper body.

9. Back pedal. (DYNAMIC)
While keeping feet under hips, take small steps to move backwards rapidly, concentrating on the pushing leg extension action.

10. Adductor stretch. (STATIC)
In a seated position with an erect spine, touch soles of feet together, bend knees, and allow knees to drop.

Appendix D

Vertical Jump protocol

Standardized protocols for testing will be followed according to methods previously described by Semenick (1990).

The vertical jump will be measured using a Vertec jump device (Hilliard, OH). Subjects will be instructed to stand with feet flat on the ground, extend their arm and mark a standing reach height. After assuming a crouch position, each subject will then be instructed to spring upward and touch the device at the highest possible point. A vertical jump height score will be calculated as the distance from the highest point reached during standing and the highest point reached during the vertical jump. Participants will then rest standing for 3 minutes and then repeat the jump a second time. This process will be repeated once more as the subjects performs the third jump.

Semenick, D.(1990) The vertical jump. *National Strength Conditioning Journal*. 12(3): 68-69.

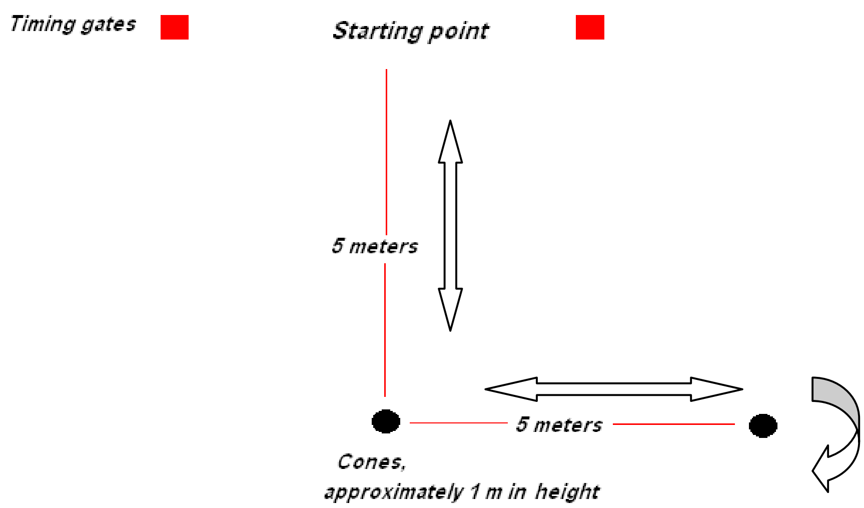
Appendix E

L-run protocol

Standardized protocols for testing will be followed according to methods previously described by Webb et al (1983).

Three cones will be utilised approximately 1 m in height, placed 5 m apart in the shape of an L. The sprint will begin at the "go" command: "1, 2, 3, go." From a standing start, dominant foot forward subjects will run forward 5 m turn to their left, run forward 5 m, turned 180 degrees and followed the same course to return to the finish line. Subjects were instructed to run as quickly as possible throughout. The subjects will be instructed to run as fast as possible for the duration of the L-run with a prior instruction not brake until after passing the finishing mark. Participants will then rest standing for 3 minutes and then repeat the sprint a second time. This process will be repeated once more as the subjects performed the third sprint trial. Timing gates will be used to record times.

Diagram of L-run



Webb, P., & Lander, J. (1983). An economical fitness testing battery for high school and college rugby teams. *Sports Coach*, 7, 44 – 46.

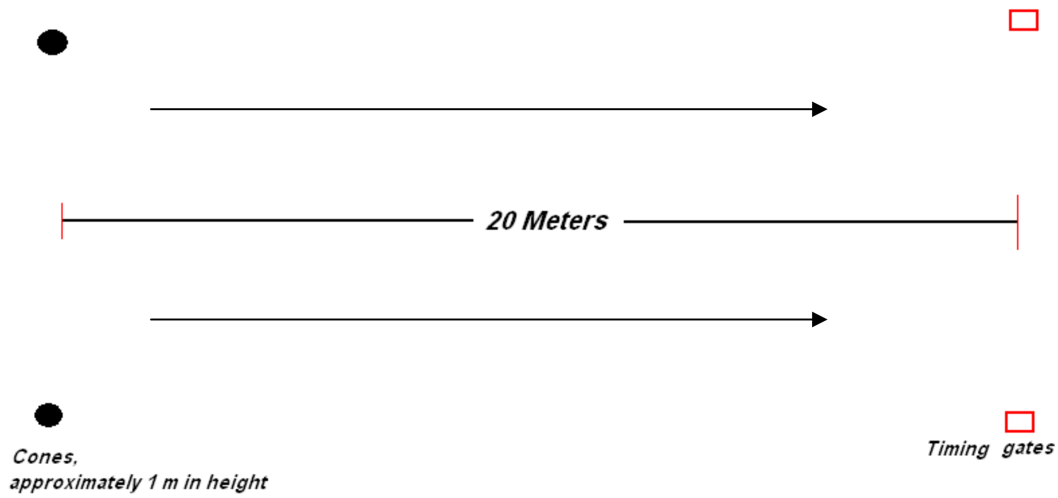
Appendix F

20 meters sprint protocol

Standardized protocols for testing were followed according to methods previously described by Walsh et al (2003)

The 20 meters sprint test will start from an upright standing position with dominant foot forward. The sprint will begin at the "go" command: "1, 2, 3, go." Subjects will be instructed to run as fast as possible for 20 m with a prior instruction not brake until after passing the 20-m mark. Participants will then rest standing for 3 minutes and then repeat the sprint a second time. This process will be repeated once more as the subjects performed the third sprint trial. Timing gates will be used to record times.

Diagram of 20 meters sprint



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University of Chester

Pre-test Questionnaire

The acute effects of differing warm-up protocols on sports specific actions of youth rugby union players

Researcher : *Paul Bailey*

Name:________________________________ Test date:________________

Address:____

Contact number:___________________________ Date of birth:___________

In order to ensure that this study is as safe and accurate as possible, it is important that each potential participant is screened for any factors that may influence the study. Please circle your answer to the following questions:

1. Has your doctor ever said that you have a heart condition *and* that you should only perform physical activity recommended by a doctor? YES/NO
2. Do you feel pain in the chest when you perform physical activity? YES/NO
3. In the past month, have you had chest pain when you were not performing physical activity? YES/NO
4. Do you lose your balance because of dizziness *or* do you ever lose consciousness? YES/NO
5. Do you have bone or joint problems (e.g. back, knee or hip) that could be made worse by a change in your physical activity? YES/NO
6. Is your doctor currently prescribing drugs for your blood pressure or heart condition? YES/NO
7. Are you pregnant, or have you been pregnant in the last six months? YES/NO
8. Have you injured your hip, knee or ankle joint in the last six months? YES/NO
9. Do you know of any other reason why you should not participate in physical activity? YES/NO

Thank you for taking your time to fill in this form. If you have answered 'yes' to any of the above questions, unfortunately you will not be able to participate in this study.

Appendix H

Consent form

Title of Project: The acute effects of differing warm-up protocols on sports specific actions of youth rugby union players

Name of Researcher: Paul Bailey

Please initial box

1. I confirm that I have read and understand the information sheet dated …………for the above study and have had the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason and without my legal rights being affected. ☐

3. I agree to take part in the above study. ☐

Name of Participant	Date	Signature
Name of parent or guardian	Date	Signature
Name of Person taking consent (if different from researcher)	Date	Signature
Researcher	Date	Signature

1 for participant; 1 for researcher

Appendix I

Participant information sheet

The effects of differing warm-up protocols on sports specific actions of youth rugby union players

Your son has been invited to take part in a research study. Before you decide, it is important to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss with the intended subject. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of the study?

The purpose of the study is to examine the differing effects of varying warm-up techniques on the sports specific actions of youth rugby union players. This data will help to identify the most effective warm-up for optimizing performance. The information generated will be valuable to coaches, young athletes and physical education teachers who typically administer warm up activities.

Why has my son been chosen?

Definitive scientific evidence supporting one method of warm up technique over another is at presently lacking. Particularly in youth sports, warm up techniques depend largely on the traditional methods of the coach. Furthermore limited research exists for warm ups on performance related to the demands of rugby union. In order to address these issues and determine the ideal method of warming up youth performers a youth population needs to be investigated. The age group of 12-13 has been chosen as this is the official age group where full contact rugby can be played.

Does my son have to take part?

It is up to you and your son to decide whether or not to take part. If you decide that your son can take part you will be given this information sheet to keep and be asked that you and your son sign a consent form. If you and your son decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of care you receive in any way.

What will happen to my son if we decide to take part?

If you decide to take part, you and your son will be given this information sheet to keep and asked to both sign the consent form. The research will take place over 4 weeks as part of your son’s weekly rugby training session supervised by the team coach Christopher Evans. Your son will engage in several safe warm up procedures followed by 3 short fitness tests designed to measure speed, power and agility. The testing procedures will take a maximum of 30 minutes and will be used as a warm up for the remained of the training session. Scores from the fitness tests will be used to establish which warm up technique resulted in the best performance. None of the subjects in the research will be identifiable in the final report.*

What are the possible disadvantages and risks of taking part?
There are no disadvantages or risks foreseen in taking part in the study.

What are the possible benefits of taking part?
The data from this study will help to identify the most effective warm-up for optimizing performance for youth rugby and similar sports. Information generated will be valuable to young athletes helping to increase their performance in training and on match days.

What if something goes wrong?
If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this study, please contact the Dean of Applied Science and Health, Sarah Andrew, University of Chester, Parkgate Road, Chester, CH1 4BJ, 01244 513402 (messages will be taken and calls returned asap).

If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence (but not otherwise), then you may have grounds for legal action but you may have to pay for this.

Will my son's taking part in the study be kept confidential?
All information which is collected about you during the course of the research will be kept strictly confidential so that only the researcher carrying out the research will have access to such information.

What will happen to the results of the research study?
The results will be written up into a report. It is hoped that the findings may be used to improve the quality of warm up procedures for youth performers. Individuals who participate will not be identified in any subsequent report or publication.

Who may I contact for further information?
If you would like more information about the research before you decide whether or not you would be willing to take part, please contact:

Paul Bailey

University of Chester,
Parkgate Road,
Chester
CH1 4BJ

Phone: 01244 513402 – (messages will be taken and calls returned asap)

Thank you for your interest in this research.

Appendix J

Statistic output

Paired Samples Tests

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Static sprint - Dynamic Sprint	.27550	.46182	.10327	.05936	.49164	2.668	19	.015
Pair 2	Static sprint - Static dynamic sprint	.06300	.37820	.08457	-.11400	.24000	.745	19	.465
Pair 3	Dynamic Sprint - Static dynamic sprint	-.21250	.41893	.09368	-.40857	-.01643	-2.268	19	.035

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Static Jump - Dynamic Jump	-2.1575	2.0856	.4663	-3.1336	-1.1814	-4.626	19	.000
Pair 2	Static Jump - Static dynamic jump	.2400	1.4032	.3138	-.4167	.8967	.765	19	.454
Pair 3	Dynamic Jump - Static dynamic jump	2.3975	2.8040	.6270	1.0852	3.7098	3.824	19	.001

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Satic Lrun - Dynamic Lrun	.32100	.40105	.08968	.13330	.50870	3.579	19	.002
Pair 2	Satic Lrun - Static dynamic Lrun	.02000	.15835	.03541	-.05411	.09411	.565	19	.579
Pair 3	Dynamic Lrun - Static dynamic Lrun	-.30100	.43269	.09675	-.50350	-.09850	-3.111	19	.006

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
factor1	Sphericity Assumed	69.736	2	34.868	14.753	.000
	Greenhouse-Geisser	69.736	1.312	53.157	14.753	.000
	Huynh-Feldt	69.736	1.370	50.892	14.753	.000
	Lower-bound	69.736	1.000	69.736	14.753	.001
Error(factor1)	Sphericity Assumed	89.811	38	2.363		
	Greenhouse-Geisser	89.811	24.926	3.603		
	Huynh-Feldt	89.811	26.035	3.450		
	Lower-bound	89.811	19.000	4.727		

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
factor1	Sphericity Assumed	1.294	2	.647	10.401	.000
	Greenhouse-Geisser	1.294	1.210	1.069	10.401	.002
	Huynh-Feldt	1.294	1.248	1.036	10.401	.002
	Lower-bound	1.294	1.000	1.294	10.401	.004
Error(factor1)	Sphericity Assumed	2.363	38	.062		
	Greenhouse-Geisser	2.363	22.996	.103		
	Huynh-Feldt	2.363	23.717	.100		
	Lower-bound	2.363	19.000	.124		

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
factor1	Sphericity Assumed	.834	2	.417	4.702	.015
	Greenhouse-Geisser	.834	1.900	.439	4.702	.016
	Huynh-Feldt	.834	2.000	.417	4.702	.015
	Lower-bound	.834	1.000	.834	4.702	.043
Error(factor1)	Sphericity Assumed	3.368	38	.089		
	Greenhouse-Geisser	3.368	36.107	.093		
	Huynh-Feldt	3.368	38.000	.089		
	Lower-bound	3.368	19.000	.177		